CONSTRAINING COSMOLOGICAL PARAMETERS WITH CMB MEASUREMENTS

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The current enthusiam to measure fluctuations in the CMB power spectrum at angular scales between 0.1 and 1° is largely motivated by the expectation that CMB determinations of cosmological parameters will be of unprecedented precision. In such circumstances it is important to estimate what we can already say about the cosmological parameters. In two recent papers (Lineweaver *et al.* 1997a & 1997b) we have compiled the most recent CMB measurements, used a fast Boltzmann code to calculate model power spectra (Seljak & Zaldarriaga 1996) and, with a χ^2 analysis, we have compared the data to the power spectra from several large regions of parameter space. In the context of the flat models tested we obtain the following constraints on cosmological parameters: $H_o = 30^{+13}_{-9}$, $n = 0.93^{+0.17}_{-0.16}$ and $Q = 17.5^{+3.5}_{-2.5}\,\mu$K. The n and Q values are consistent with previous estimates while the H_o result is surprisingly low.

1 Method

With two new CMB satellites to be launched in the near future (MAP $\sim$ 2001, Planck Surveyor $\sim$ 2005) and half a dozen new CMB experiments coming on-line (see contribution of Lyman Page to this volume), it is important to keep track of what we can already say about the cosmological parameters. In Lineweaver *et al.* (1997a) we considered COBE-normalized flat universes with $n = 1$ power spectra. We used predominantly goodness-of-fit statistics to locate the regions of the $H_o - \Omega_b$ and $H_o - \Lambda$ planes preferred by the data. In Lineweaver *et al.* (1997b) we obtained χ^2 values over the 4-dimensional parameter space $\chi^2(H_o, \Omega_b, n, Q)$ for $\Omega = 1$, $\Lambda = 0$ models. Projecting and slicing this 4-D matrix gives us the error bars around the minimum χ^2 values. Here we summarize several of our most important results.

2 Results and Discussion

One of the difficulties in this analysis is the 14% absolute calibration uncertainty of the 5 important Saskatoon points which span the dominant adiabatic peak in the spectrum (Figure 1). We treat this uncertainty by doing the analysis three times: all 5 points at their nominal values ('Sk0'), with a 14%

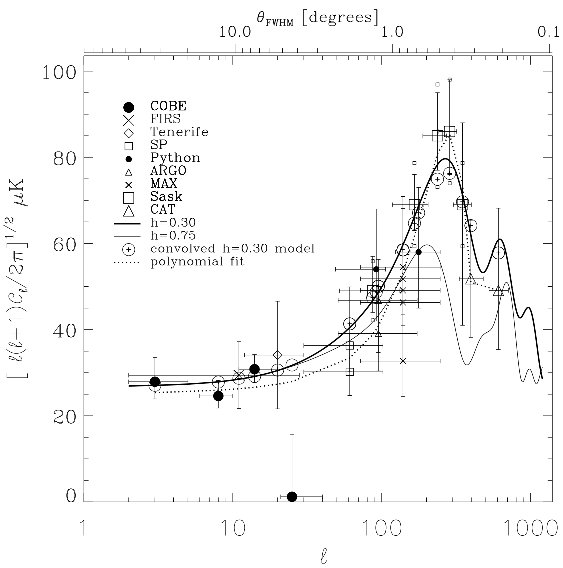

Figure 1. CMB Data
A compilation of 24 of the most recent measurements of the CMB angular power spectrum. Models with $h = 0.30$ and $h = 0.75$ are superimposed (both are $\Omega = 1$, $\Omega_b = 0.05$, $n = 1$ $Q = 18$ μK models). The dotted line is a 5th order polynomial fit to the data. The low-h value is favored. MAP and Planck Surveyor are expected to yield precise spectra for $\theta_{FWHM} \gtrsim 0°.3$ and $\theta_{FWHM} \gtrsim 0°.2$ respectively (see angular scale marked at the top). Figure from Lineweaver *et al.* (1997a).

increase ('Sk+14') and a 14% decrease ('Sk-14'). Sk+14 and Sk-14 are indicated by the small squares in Figure 1 above and below the nominal Saskatoon points. Leitch *et al.* (1997) report a preliminary relative calibration of Jupiter and CAS A implying that the Saskatoon calibration should be $-1\% \pm 4\%$. Reasonable χ^2 fits are obtained for Sk0 and Sk-14.

In the context of the flat models tested, our χ^2 analysis yields: $H_o = 30^{+13}_{-9}$, $n = 0.93^{+0.17}_{-0.16}$ and $Q = 17.5^{+3.5}_{-2.5}$ μK. The H_o result is shown in Figure 2. The n and Q values are consistent with previous estimates while the H_o result is surprisingly low. For each result, the other 3 parameters have been marginalized over. This H_o result has a negligible dependence on the Saskatoon calibration, i.e., lowering the Saskatoon calibration from 0 to -14% does not raise the best-fitting H_o in flat models. The inconsistency between this low H_o result and $H_o \sim 65$ results will not easily disappear with a lower Saskatoon calibration. Our results are valid for the specific models we considered: $\Omega = 1$, CDM dominated, $\Lambda = 0$, Gaussian adiabatic initial conditions, no tensor modes, no early reionization, $T_o = 2.73$ K, $Y_{He} = 0.24$, no defects, no HDM.

There are many other cosmological measurements which are consistent with such a low value for H_o (Bartlett *et al.* 1995, Liddle *et al.* 1996). For example, we calculated a joint likelihood based on the observations of galaxy cluster baryonic fraction, big bang nucleosynthesis and the large scale density fluctuation shape parameter, Γ. We obtained $H_o \approx 35^{+6}_{-5}$.

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References

1. C.H. Lineweaver, D. Barbosa, A. Blanchard & J.G. Bartlett *A & A*, in press astro-ph/9610133 (1997a).
2. C.H. Lineweaver, D. Barbosa, A. Blanchard & J.G. Bartlett *A & A*, submitted astro-ph/9612146 (1997b).
3. U. Seljak & M. Zaldariaga *Ap. J.*, 469, 437 (1996).
4. E. Leitch *et al.* in preparation (1997).
5. A. Liddle *et al. M.N.R.A.S.*, 281, 531, (1996).
6. J.G. Bartlett, A. Blanchard, J. Silk, & M.S. Turner Science, 267, 980 (1995).

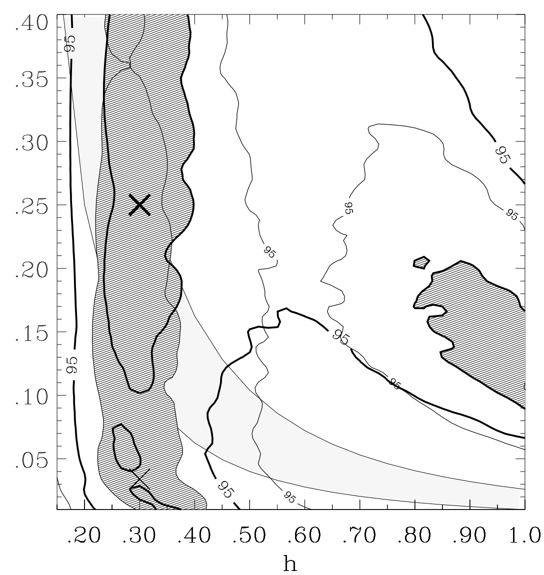

Figure 2. Constraints on Hubble's Constant The dark grey areas denote the regions of parameter space favored by the CMB data. They are defined by $\chi^2_{min}+1$ for Sk0 and Sk-14 (minima marked with thick and thin 'x' respectively). '95' denotes the $\chi^2_{min}+4$ contours for Sk0 (thick) and Sk-14 (thin). The light grey band is from big bang nucleosynthesis ($0.010 < \Omega b\, h^2 < 0.026$). The parameters n and Q have been marginalized. In the H_o result quoted, we neglect the region at $H_o \sim 100$ with $\Omega_b \sim 0.15$. This figure shows clearly that lowering the calibration by 14% *does not* favor higher values of H_o (Figure from Lineweaver *et al.* 1997b).